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TECHNICAL EFFICIENCY OF THE RIPARIAN BEEKEEPERS OF THE COMPLEX OF PROTECTED AREAS PÔ-NAZINGA-SISSILI IN BURKINA FASO

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ABSTRACT

This paper attempted to analyse determinants of the technical efficiency of beekeepers in villages impacted by the creation of elephant corridor called Corridor No. 1 of the Pô-Nazinga-Sissili protected area complex in southern Burkina Faso. The data used in this analysis were collected from a sample of 52 beekeepers in July and August 2018. A Cobb-Douglas type honey production function with inefficiency effects was estimated for this purpose. The results showed that 75% of the discrepancy between potential and actual honey production would be due to beekeepers' technical inefficiency and that the average score of beekeepers' inefficiency effects was 0.78. It should be noted that the location of the hives, the number of years of beekeeping training received as well as the possession of a beekeeping suit are the significant factors that increase the efficiency level of the beekeepers. On the other hand, membership to a beekeepers' association has a negative effect on honey production. The results highlight that locating hives within one kilometer of the elephant corridor may significantly improve the technical efficiency of the beekeepers. However, the survival of these pachyderms is threatened because of human reprisals against them following their possible overflow into the riparian villages. Thus, an effective and sustainable policy aiming at both the conservation of the forest and an improvement of the incomes of the riparian households could be implemented by encouraging beekeepers to locate their hives next to the protected forests. This should increase their yields and it could maintain elephants within forests.

Keywords: *Beekeeping, technical efficiency, protected areas, Burkina Faso.*

INTRODUCTION

Like other sub-Saharan African countries, the fight against poverty is a concern for Burkina Faso. According to the National Institute of Statistics and Demography (INSD), the monetary poverty incidence in Burkina Faso stood at 47.50% in rural areas compared to 13.70% in urban areas in 2014 (INSD, 2020). Rural populations combine several livelihood sources to overcome their economic and structural problems. Exploitation of non-timber forest products (NTFPs) constitutes an opportunity to diversify their income and subsistence sources. According to the Food and Agriculture Organization of the United Nations (FAO), a NTFP is defined as any product of biological origin other than wood originating from forests, other wooded land and other trees outside forests (FAO, 1999). As stated by Angelsen et al. (2014), many NTFPs including honey also contribute to building rural households' resilience to food and monetary shocks.

According to the Technical Secretariat for Beekeeping (STA) of Burkina Faso, the country recorded an annual production of nearly 500 tonnes on average over the period 2011-2015 (STA, 2019). This production reached the maximum of 1000 tonnes in 2018 with a contribution of about 9% to the agricultural gross domestic product (INSD, 2020; STA, 2019). Nevertheless, the practice of modern beekeeping in the country seems to be at embryotic stage and occupies less than 1% of the national population. In 2019, only 16,261 beekeepers with 132,057 hives were identified, 82% of which were traditional against 18% modern, with a total production of 565.6 tonnes of raw honey. It was remarked that two traditional hives provide the same yield as one modern hive, and the yield per modern hive remains below 15 kg of raw honey (equivalent to 6 litres). This yield is much lower than what is observed in many other countries over the world, such as Madagascar, where the yield per hive goes to 50 litres (Lagarde et al., 2004).

Beekeeping yields seem to vary with vegetation cover in Burkina Faso. A study on honey production in villages bordering the Pô-Nazinga-Sissili Protected Areas Complex (PONASI-PAC) found that beekeeping yields are low compared to the national average. The quantity of honey produced per hive oscillates between 6 and 12 litres [Association Nature et Développement (NATUDEV, 2017)]. This is why an investigation into the causes of low beekeeping yields as technical efficiency of beekeepers is still of current interest for the economic development of the villages around the PONASI-PAC. From a theoretical point of view, a production unit is said to be efficient if it produces the maximum possible output from its basket of inputs or if it can produce a given quantity of output by using the minimum quantity of inputs (Atkinson and Cornwell, 1994). Hence, the question of the present research is: what are the determinants of the technical efficiency of beekeepers in the villages bordering the PONASI-PAC corridor No. 1? The objective of this research is to identify the determinants of the technical efficiency of beekeepers in the vicinity of the PONASI-PAC corridor No. 1. Our research hypothesis states that the location of hives near forests improves the technical efficiency of beekeepers.

MATERIAL AND METHODS

Theoretical framework of technical efficiency analysis

Concept of technical efficiency was initiated in the mid-twentieth century by Debreu (1951) and Farrell (1957). At firm level, technical efficiency is estimated through either the cost frontier, the profit frontier or the production frontier. The present research is based on the production frontier of beekeepers. In economic theory, two categories of approaches are used to specify the production frontier, namely non-parametric approach and the so-called parametric approach (Kumbhakar et al., 2015).

Non-parametric approaches do not impose any particular specification on the production function. They have the advantage of being able to consider several outputs and inputs at the same time in a specific analysis (Ambapour, 2001). This category of approaches includes the Data Envelopment Analysis method and the Free Disposal Hull method. However, these approaches do not take into account the effect of measurement errors and random shocks in the evaluation of the technical inefficiency of producers.

As for parametric approaches, the focus is on econometric techniques for estimating production boundaries. They consist of an econometric estimation of the best practice frontier. These approaches can be stochastic (respectively deterministic) if there is presence (respectively absence) of a stochastic term capturing the hazards' effect not controllable by the producer in its production frontier. Regardless the limitations or advantages associated with each approach, the stochastic frontier approach is adopted in this research. This approach was introduced by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977). These authors admit that the error term has two components: a component attributable to the producer noted u_i and another component which captures the effect of hazards on the output noted v_i. It is the u_i component that measures technical inefficiency. Thus, production frontier expression is given by equation (1).

$$y_i = f(x_i, \beta)e^{v_i - u_i} \quad (1)$$

where β is a vector of unknown parameters; $f(x_i, \beta)$ is the production function; x_i represents the inputs used by producer i. The interest of the analysis of technical efficiency by the stochastic production frontier approach is not only limited to the evaluation of efficiency levels. It allows also identification of the factors likely to influence this technical efficiency (Kumbhakar et al., 2015). For this purpose, authors such as Battese and Coelli (1995) and Abedullah et al. (2007) have formulated the technical inefficiency function as expressed in equation (2).

$$u_i = z_i\alpha + w_i \quad (2)$$

where z_i is a vector of variables explaining the producer's inefficiency u_i; α is the vector of unknown parameters and w_i is a random term representing the estimation errors of technical inefficiency. In equation (1), $f(x_i, \beta)$ can generally take several forms, of which the Cobb-Douglas and translogarithmic forms are the most commonly used. Unlike the Cobb-Douglas function, the translogarithmic function allows to see the joint effect of the production factors taken two by two on the observed output. In practice, a test for the functional form choice of the production function and a test for the existence of technical inefficiency are usually performed in technical efficiency analyses. In our analysis, the results of these tests indicate that a Cobb-Douglas specification of the production frontier is appropriate and the assumption of no inefficiency in the model is rejected. This specification has been used by many authors such as Ahmed et al. (2014).

Data and Empirical Model

This research used cross-sectional primary data related to the 2017-2018 beekeeping season. They were collected in July and August 2018 using a structured questionnaire administered to the totality of 52 modern beekeepers registered. The study area consists of six villages (Bourou, Kollo, Oualem, Saro, Tiakané, and Yaro) impacted by the creation of the PONASI-PAC Corridor No. 1. This corridor permits elephants to move from the Pô National Park to the Nazinga Ranch and back. Table 1 summarises the definitions of the study variables, their expected effects on the explained variable (honey production or technical inefficiency), and the authors whose findings support directly or indirectly these effects.

Table 1. Description of the variables of the stochastic production frontier

Variable	**Unit**	**Definition**	**Expected sign**	**References**
		PRODUCTION FRONTIER		
PRODUCT	Litre	Volume of honey produced by the beekeeper		
RUCHE	Natural number	Number of hives used by the beekeeper	+	
MO	Hour	Time taken by the beekeeper to monitor his hives and harvest the honey	+/-	
		TECHNICAL INEFFICIENCY		
ALPHABE	Binary	1=the beekeeper is literate and 0 otherwise	-	Abedullah et al. (2007)
FORMAAPIC	Natural number	Number of years the beekeeper has been trained in beekeeping	-	Becker (1964)
APGROUP	Binary	1=the beekeeper is a member of a beekeeping association and 0 otherwise	-	Chebil et al. (2013)
POSCOMB	Binary	1=the beekeeper has his own beekeeping suit and 0 otherwise	-	
FORET	Binary	1= the beekeeper has hives within 1 km of PONASI-PAC forests and 0 otherwise	-	Nombre (2003)

*Source: Authors' elaboration based on field survey data

The empirical model for investigating the technical efficiency of beekeepers is based on the specification of equations (1) and (2). In equation (1), we consider two production factors which are the number of modern hives possessed by each beekeeper noted RUCHE and the time that this beekeeper devotes to the follow-up of his hives and the harvest of honey noted MO with a Cobb-Douglas specification of $f(x_i, \beta)$. For equation (2), the inefficiency variables group the beekeeper's literate status noted ALPHABE, the number of years in which he considers he has benefited from beekeeping training noted FORMAAPIC, his membership in an association noted APGROUP, his own beekeeping suit endowment noted POSCOMB and the proximity of his hives to the components of PONASI-PAC noted FORET during the 2017-2018 beekeeping season. Thus, the empirical model combines equations (3) and (4).

$$ln\ \mathrm{PRODUCT}_i = \beta_0 + \beta_1\ ln\mathrm{RUCHE}_i + \beta_2\ ln\mathrm{MO}_i + v_i - u_i \quad (3)$$

$$u_i = \alpha_0 + \alpha_1 \mathrm{ALPHABE}_i + \alpha_2 \mathrm{FORMAAPIC}_i + \alpha_3 \mathrm{APGROUP}_i + \alpha_4 \mathrm{POSCOMB}_i + \alpha_5 \mathrm{FORET}_i + w_i \quad (4)$$

Following Combary and Savadogo (2014) and N'Gbo (1994), the one-step maximum likelihood estimation approach is used in the present research. In practice, the *sfmodel* command developed by Kumbhakar et al (2015) with the Stata 16.0 package is applied.

RESULTS AND DISCUSSION

Results show that the annual average quantity of honey produced in the six villages is about 36.5 litres per beekeeper. The least diligent beekeeper produced five litres while the most diligent beekeeper produced 270 litres per annum. The average number of hives per beekeeper is five. Along a year, the working hours for the monitoring and the harvest of honey are 50.93 on average per beekeeper. On average, the beekeepers have received at least one beekeeping training over three years. Results indicate also that, 76.9% of beekeepers are literate, and 76.9% are members of a beekeeping association. In addition, only 59.6% of beekeepers use their own beekeeping suits. Only 38.7% of the beekeepers have placed their hives within one kilometre of the PONASI-PAC.

Results from econometric analysis (Table 2) show that gamma (γ) equals to 0.751 and it is statistically significant. Thus, 75,10% of the difference between the potential yield of honey and the current yield would be attributable to technical inefficiency of the beekeepers. Only 24.90% of this difference would have been caused by factors that cannot be controlled by the beekeepers. Besides, the estimated coefficients of the honey production function are significantly different from zero. As these coefficients are directly interpreted in terms of elasticity, an increase of 1% in the number of hives leads to an increase of 1.238 % in the quantity of honey produced, *ceteris paribus*. This result was expected and conforms to the reality of the beekeeping activity. In the same way, an increase in working time of 1% leads to a decrease of 0.752% in the quantity of honey produced by the beekeepers, *ceteris paribus*. This is also aligned to the reality of beekeeping activity. More working hours would expose the beekeeper to insect attacks and may provoke bee desertion from the hives. It may also increase bee mortality if the beekeeper tries to take a lot of time during visits and harvesting, as bees do not like to be disturbed. The beekeeper must therefore optimise the time he spends on his hives.

The Table 2 shows also results from econometric estimation of the beekeeper technical inefficiency model. The results show that four of the five socio-economic characteristics of the beekeepers are found to be the primary factors explaining significantly the beekeepers' technical inefficiency. As it was expected, the number of years of training received, the use of one's own beekeeping suit as well as the location of the hives near the components of the PONASI-PAC influence negatively the technical inefficiency. This implies that these factors affect positively the technical efficiency of the beekeepers and honey production. On the other hand, and in contrast to our expectations, the membership to a beekeepers' association influences positively the beekeeper's inefficiency and, consequently, it affects negatively technical efficiency and honey production. Our results point also to a positive but not significant effect of beekeeper's literate status on technical inefficiency and honey production.

Table 2. Estimation of the stochastic Cobb-Douglas production frontier of beekeepers

Notice that (i) standard errors are in parentheses and; (ii) *** $p<0.01$, ** $p<0.05$, * $p<0.1$

VARIABLES	frontier	usigmas	vsigmas
ALPHABE		1.945	
		(1.195)	
FORMAAPIC		-1.281***	
		(0.480)	
APGROUP		2.098*	
		(1.186)	
POSCOMB		-1.975**	
		(0.914)	
FORET		-1.907**	
		(0.958)	
ln (RUCHE)	1.238***		
	(0.221)		
ln (MO)	-0.752***		
	(0.173)		
Constant	0.051	-1.004	-2.106***
	(0,083)	(1.249)	(0.261)
Observations	52	Wald chi2(2)	33.08***
Log likelihood	-29.426	Gamma (γ)	0.751***
Average efficiency score	0.778		

Source: Authors' elaboration based on field survey data

Following Battese et al. (1989), results from econometric analysis show that the average efficiency score is estimated to 0.778 in our study. This means that beekeepers produce on average 77.8% of the maximum (or potential) output. It implies that honey production can be increased by 22.2% by a better allocation of available inputs, without the need for additional amounts of inputs. In this study, the technical efficiency among beekeepers ranges from 19.3% to 100%.

CONCLUSION

This paper analyses technical efficiency of beekeepers in rural Burkina Faso. A stochastic Cobb-Douglas production function was specified and estimated for identifying the determinants of honey production function and assessing the sources of technical inefficiency of beekeepers in the surroundings of PONASI-PAC Corridor No.1. Our research results highlighted that 75% of the difference between the potential yield of honey and the current yield would be due to technical inefficiency of the beekeepers. Also, an average efficiency score of 0.778 was estimated. The location of the hives next to the protected forests, the number of years of beekeeping training received and the possession of a beekeeping suit are the factors that increase the technical efficiency level of beekeepers. The results showed also that belonging to a beekeepers' association has a negative effect on the production of honey.

In view of the results obtained, the implications in terms of economic policies are the following: first, beekeepers should be encouraged to place their hives near forests. Secondly, it should be ensured that each beekeeper has a beekeeping suit. Finally, beekeepers should be trained or retrained annually.

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